Adriatic Mesoscale Experiment (AMEX)

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LONG-TERM GOALS

To contribute to the understanding of the dynamics of marginal seas such as the Adriatic by collecting and interpreting accurate Lagrangian observations of currents and satellite measurements of water mass properties (e.g., temperature, salinity, chlorophyll concentration). In particular, to study the variability of the surface velocity and temperature/chlorophyll fields in selected basins of the Mediterranean at the meso-, seasonal and interannual scales and to assess the impact of the wind forcing and fresh water runoffs.

OBJECTIVES

The main objective of the AMEX project is to quantify the kinematic and dynamic properties of the northern and middle Adriatic (NMA) Sea. In particular the experimental work includes the following tasks based on data provided by drifters and ancillary remote sensing observations (satellites and high-frequency coastal radars):

- Describe the NMA surface circulation variability (Eulerian and Lagrangian statistics, major scales of variability, particle dispersion, etc.) and separate this variability into mean (over 6 months), synoptic (~10 days), mesoscale (a few days) and high-frequency (tidal, seiches, inertial) components;

- Describe the spatial structure and temporal variability of predominant mesoscale features, such as the cold filaments rooted of the Croatian coast (NAF and MAF), and the instability of the Po River Plume and WAC;

- Relate the mesoscale flow characteristics to the thermal and pigment signatures;

- Study the effect of wind forcing (Bora and Sirocco conditions) and bathymetry on the above-mentioned mesoscale circulation features;

- Determine the contribution of mesoscale circulation to the spreading and flushing of buoyant waters of riverine origin, and to lateral heat transport;

Report Documentation Page

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14. ABSTRACT

To contribute to the understanding of the dynamics of marginal seas such as the Adriatic by collecting and interpreting accurate Lagrangian observations of currents and satellite measurements of water mass properties (e.g., temperature, salinity, chlorophyll concentration). In particular, to study the variability of the surface velocity and temperature/chlorophyll fields in selected basins of the Mediterranean at the meso-, seasonal and interannual scales and to assess the impact of the wind forcing and fresh water runoffs.

15. SUBJECT TERMS

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- Set up a new methodology using drifters, HF radars and remote sensing to study the mesoscale variability in coastal environments and marginal seas.

APPROACH

1) Assess the efficiency and usefulness of surface drifters equipped with GPS receivers.

2) Use a "random flight" model (Gaussian-Markov process) to seek an optimized drifter deployment strategy to map the mean flow and eddy variability and to quantify particle dispersion (Lagrangian statistics) in the NMA.

3) Deploy more than 100 drifters to monitor the surface circulation in most areas of the NMA for about a year (September 2002 to September 2003).

4) Estimate surface circulation statistics, both Eulerian and Lagrangian, for the entire NMA area. For example, produce mean circulation and eddy variability maps for each season and with spatial resolution of 10-20 km. Estimate Lagrangian statistics such as the integral time and length scales and eddy diffusivities.

5) Describe the spatial structure and temporal variability of the filaments, NAF and MAF. Eulerian maps of mean velocity and variance will be created on a monthly basis and with 5-10 km spatial resolution. Estimate one and two-particle dispersion statistics from the data given by the drifters deployed in clusters.

6) Compare qualitatively and quantitatively (regressions) the drifter data with the SST/pigment structures obtained from satellite data and with the surface velocity maps provided by high-frequency coastal radars.

7) Use the combined drifter and radar data to study the temporal variability and spatial structure of the surface circulation and in particular to assess the influence of wind forcing and river runoffs.

WORK COMPLETED

1) A statistical numerical model based on Langevin equation was used to find optimized drifter deployment strategies in the northern and middle Adriatic. This model uses the statistics inferred from the historical Adriatic drifter data base spanning 1990 –1999. In practice, the numerical drifters are integrated using a constant Eulerian mean velocity field plus a time-varying fluctuating component in which the characteristics of the variability ellipses and the Lagrangian integral time scale are considered. A total of 100 ensembles (or realizations) of more than 120 drifters integrated up to 150 days have been produced. They were released between September 2002 and June 2003 in groups of three at various key locations throughout the domain of interest.

2) CODE drifters equipped with GPS receivers were tested in the Tyrrhenian and Adriatic Seas. Details of data format and data telemetry were decided with the drifter manufacturers to guarantee high-quality GPS location data with sampling intervals of 30 minutes or 1 hour.

3) About 100 drifters we purchased from several companies in North America. These include regular and GPS CODE drifters, GPS SVP drifters with holey-sock drogue centered at 50 m depth, GPS CODE drifters with 50-m long thermistor chains, and SVP/OCM drifters with up and downward-looking radiometers.

RESULTS

1) After some trial and error tests, deployment locations for the 120 drifters were found to yield a good continuous sampling of the northern and middle Adriatic for about a year. Fig. 1 shows the predicted drifter population in the northern and middle Adriatic between September 2002 and August 2003. A mean half life time of 8 days was found due to the fact that many drifters end up quickly near the coast. This value is significantly smaller than the one estimated from past drifters (40 days). Hence our model represents a pessimistic and conservative simulation.

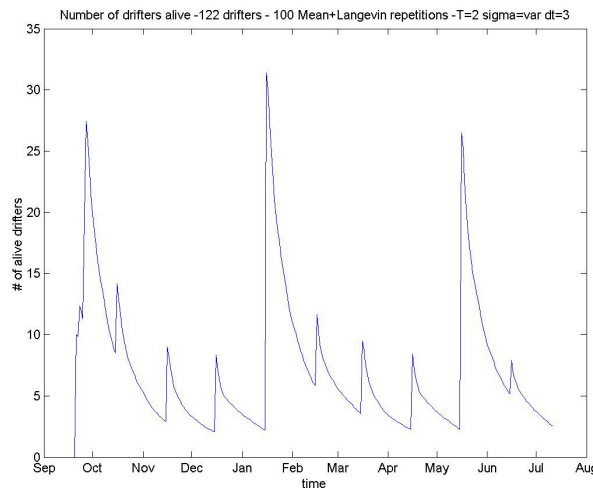Number of drifters alive -122 drifters - 100 Mean+Langevin repetitions -T=2 sigma=var dt=3

Fig. 1. Number of drifters operating in the northern and middle Adriatic Sea from September 2002 to August 2003 as predicted by the statistical model.

2) The CODE drifters equipped with GPS receivers tested in the Tyrrhenian and Adriatic Seas provided accurate position data at uniform small time intervals (30 minutes). As shown in Fig. 2, the GPS upgrade on surface drifters allows the study of high-frequency motions such as inertial and tidal currents.

IMPACT/APPLICATION

The scientific impact of this project will be to increase our understanding of the Adriatic dynamics and of the major forcing mechanisms. Future application could be the assimilation of the drifter data into numerical models in the framework of the upcoming Mediterranean Forecasting System (MFSTEP).
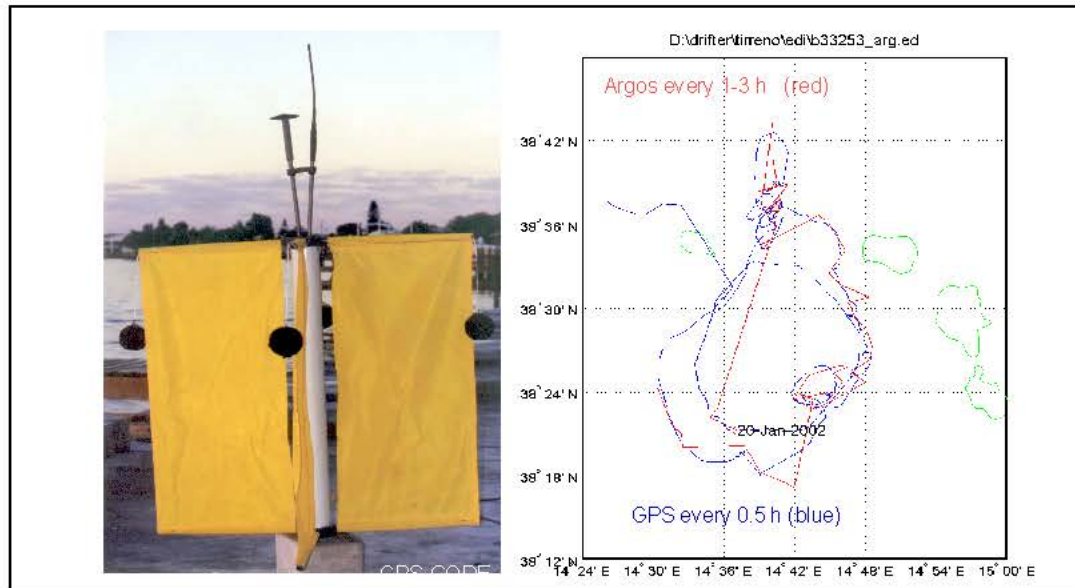
Fig. 2. GPS-CODE drifter (left) with the Argos and GPS antennas. Example of trajectories of non-GPS (red) and GPS (blue) drifters in the Tyrrhenian Sea.

TRANSITIONS

This program will set up a new methodology using drifters, high-frequency coastal radars and remote sensing to study the mesoscale variability in any coastal environments and marginal seas. It is planned to assimilate the drifter and radar data into various numerical models of the Adriatic circulation to improve forecasting skills.

RELATED PROJECTS

1) This project is strongly related to, and fully integrated in, several other projects sponsored by ONR and other funding agencies. These programs include:

    a. The ACE program (bottom-mounted ADCPs, surface salinity monitoring by airplane);
    b. The Adria02 and Adria03 cruises onboard NRV Alliance of the NATO SACLANT Undersea Research Centre;
    c. The EACE program focusing on the eastern Croatian coast;
    d. A high-frequency coastal radar program on the western Italian coast;
    e. Two cruises onboard R/V Knorr (Towed vehicles, monitoring of optical properties);
    f. A modeling program on the Adriatic mesoscale variability.

2) The drifter data collected will be used by Drs. A. Griffa and T. Ozgokmen to validate their theoretical studies of particle dispersion (ONR supported project).